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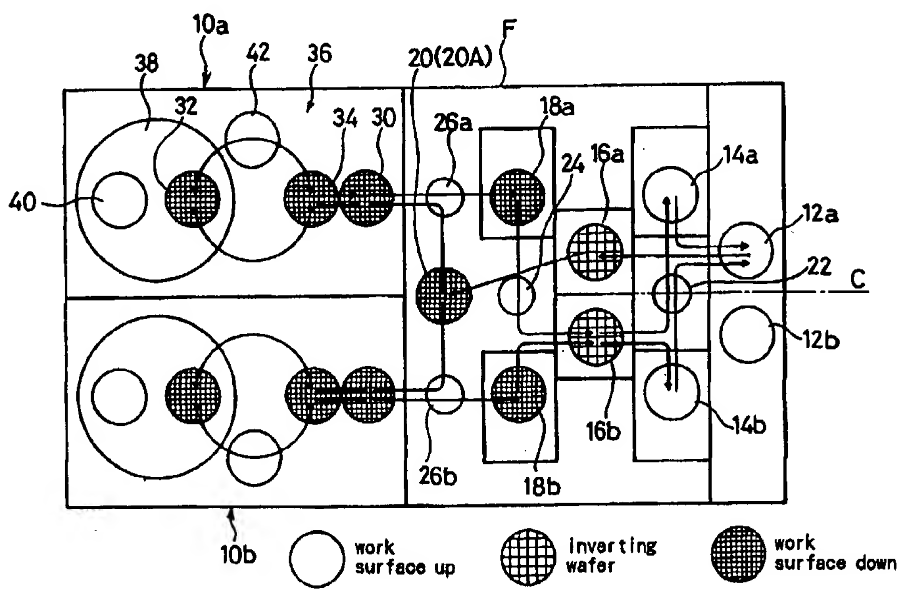


(57) Abstract

A polishing apparatus has two parallel processing lines that enables to carry out efficient parallel processing by minimizing the idle time for the turntable and maximizing the through–put. The polishing apparatus comprises at least two processing lines extending in parallel from a storage section. Each line is provided with a cleaning unit (18a, 18b) and a polishing unit (10a, 10b), a temporary storage station (20) disposed between the cleaning unit (18a, 18b) and the polishing unit (10a, 10b) and shared by the processing lines. At least two robotic devices (22, 24) are disposed on each of the processing lines for transferring workpieces among the temporary storage station (20), the polishing unit (10a, 10b) and the cleaning unit (18a, 18b).

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# DESCRIPTION

## POLISHING APPARATUS

### Technical Field

The present invention relates to polishing apparatus in general, and relates in particular to a polishing apparatus to produce flat and mirror polished surface on workpieces such as semiconductor wafers.

### Background Art

With increasing intensity of circuit integration in semiconductor devices in recent years, circuit lines have become finer and interline spacing has also been drastically reduced. With this trend for finer resolution in circuit fabrication, it is now necessary to provide precision flat substrate surface because of the extreme shallow depth of focus required in optical photolithography using stepper reproduction of circuit layout. One method of obtaining flat surface is mechano-chemical polishing carried out by pressing wafers held on a carrier against a polishing cloth mounted on a rotating turntable while dripping a solution containing abrasive powder at the interface.

Figure 11 shows a polishing apparatus disclosed in a Japanese Patent Laid-Open Publication, H9-117857. The facility is comprised by a pair of polishing units 101a, 101b disposed symmetrically at one end of a rectangular shaped floor, and a loading/unloading unit including wafer cassettes 102a, 102b disposed on the opposite end of the floor for storing wafers. Transport rails 103 are disposed along a line joining the polishing units and the loading/unloading unit, and alongside the rails 103, there are wafer inverters 105, 106 surrounded by respective cleaning units 107a, 107b and 108a, 108b.

Such a polishing apparatus, comprised by a pair of parallel processing lines arranged on both sides of the rails, is able to handle workpieces polished through single step process in

each line of the facility to improve its productivity. For those workpieces requiring double step polishing, such as compound semiconductor materials requiring polishing steps using different solutions, after completing a first polishing step through one polishing line 101a, the workpieces are cleaned next, and then transferred over to the second line 101b to carry out a second polishing step. Thus, such a polishing apparatus is able to carry out a series-operation for workpieces processed in double-step polishing, and a parallel-operation for workpieces processed in single-step polishing.

Transport of workpieces in the parallel polishing process is carried out as follows. After completing polishing operation on the polishing units 101a, 101b, the top ring (workpiece carrier) 110 rotates and moves over to the workpiece pusher (transfer device) 112 to transfer the polished workpiece. A second robot 104b transports the workpiece over to the cleaning units 107a or 107b, and receives an unpolished workpiece from the inverter 105, 106, and transfers it to the workpiece pusher 112. The top ring 110 receives the unpolished workpieces and moves back to the turntable 109 to begin polishing. A dresser 111 is provided to carry out reconditioning of the polishing cloth.

A polishing unit, such as the one shown in Figure 12, is comprised by a turntable 109 having a polishing cloth 115 bonded to its top surface, and a top ring 113 for holding and pressing a wafer onto the turntable 109. Polishing action is produced by rotating and pressing the wafers W by the top ring 113 against the rotating turntable 109 while a polishing solution Q is supplied in the interface between the wafer W and the polishing cloth 115. The polishing solution Q is held between the surface to be polished (bottom surface) of the wafer W and the polishing cloth 115 while the wafer is being polished.

In such a polishing unit, the turntable 109 and the top ring 113 are rotated at their own independent speeds, and the

top ring 113 is positioned, as shown in Figure 12, so that the inner edge of the wafer W will be off from the center of the turntable 109 at a distance "a", and the outer edge of the wafer W will be at a distance "b" from the periphery, respectively, and the wafer W is polished in this condition at high rotational speeds so that the surface of the wafer will be polished uniformly and quickly. Therefore, the diameter "D" of the turntable 109 is chosen to be more than double the radius "d" of the wafer W according to the following expression:

$$D = 2\ (d + a + b).$$

Polished wafers W are stored in the wafer cassette after having gone through one or more cleaning and drying steps. Cleaning methods for wafers include scrubbing with brush made of nylon or mohair, and sponges made of polyvinyl alcohol (PVA).

One of the problems in the existing polishing apparatus is its productivity. To increase the through-put from such a facility, the efficiency-determining processes involving polishing at the turntable 109 must be raised. However, in the existing technology, one robot 104b is required to carry out a multiple duty of removing polished wafers and supplying unpolished wafers to and from two workpiece pushers 112. This was time-consuming, resulting in idle time for the turntable 109.

Therefore, there is a need to provide, as a first objective, a polishing apparatus having two parallel processing lines that enables to carry out efficient parallel processing by minimizing the idle time for the turntable and maximizing the through-put.

Furthermore, in the existing polishing apparatus, a high relative speed between the turntable 109 and the top ring 113 is used to achieve effective polishing as well as high flatness of the wafer surface, but they may also cause micro-scratch marks on the wafers by abrasive particles contained in the polishing solution.

To prevent fine scratches, it is possible to consider utilizing two sets of turntables 109, and carry out polishing in two stages, by changing polishing parameters such as the material and abrasive characteristics of the polishing cloth 115, rotation speed of the turntable 109 and polishing solution. However, as mentioned above, the large size of the turntable 109 occupying a large installation space and high capital cost are disadvantages of such an approach, and this type of problem is expected to become more serious in the future, as larger diameter wafers become more common.

On the other hand, it is also possible to consider using one turntable by switching polishing solutions or by reducing the rotational speed to resolve existing problems, but such approaches are not expected to lead to improved productivity, because mixing of solutions may lead to poor performance and polishing time would be lengthened.

Another problem is related to cleaning of the wafers. When the wafers are scrubbed after polishing with abrasive particles, it is difficult to remove particles of sub-micron sizes, and if the adhesion force between the wafer and particles is strong, such cleaning method is sometimes ineffective for removing such particles.

Therefore, there is a need to provide, as a second objective, a compact polishing apparatus that can provide excellent flatness and efficient cleaning.

## Disclosure of Invention

These objectives of the present invention were realized in a polishing apparatus comprising: a storage section for storing a workpiece to be polished; at least two processing lines extending substantially in parallel from the storage section, each line being provided with a cleaning unit and a polishing unit; a temporary storage station disposed between the cleaning unit and the polishing unit and shared by the processing lines;

and at least two robotic devices disposed on each of the processing lines for transferring workpieces among the temporary storage station, the polishing unit and the cleaning unit.

Accordingly, each of the robotic devices is used to supply an unpolished wafer placed on the temporary storage station to a polishing unit, and a polished wafer in another polishing unit is sent directly to a cleaning unit, therefore, replacing of wafers between processes is carried out very quickly. Therefore, the productivity-limiting step of idle time for the polishing unit can be minimized, thereby enabling to increase through-put of the polishing apparatus.

In such a polishing apparatus, the polishing unit may be provided with a turntable, a top ring device and a workpiece pusher for facilitating transfer of a workpiece to and from the robotic device.

In such a polishing apparatus, the top ring device may be comprised by two top rings, which can be positioned to work with the turntable and with the workpiece pusher, and a swing arm for supporting the top rings rotatably in a horizontal plane. In this case, while one top ring is performing polishing, the other top ring is in a position to exchange a polished wafer with an unpolished wafer, so that the idle time for the turntable is reduced, thereby increasing the through-put of the facility.

In such a polishing apparatus, the polishing unit may be provided with a film thickness measuring device for remotely measuring thickness of a film formed on a workpiece being held on the top ring. Adopting this arrangement will enable to finely control the amount of material removed from the surface of the workpiece. In addition, the polishing unit may be provided with a buffing table having a buffing disk.

In another aspect of the invention, a polishing apparatus comprises: a storage section for storing a workpiece disposed at one end of an installation floor space; two polishing units disposed on opposite end of the installation floor space, each

polishing unit having a turntable, a top ring device and a workpiece pusher; at least two cleaning units for cleaning polished workpieces produced in the polishing units; and a transport device for transferring workpieces between processing units, wherein a group of polishing and cleaning units and another group of polishing and cleaning units are disposed symmetrically opposite to each other across a center line extending from said one end to the opposite end of the installation floor space, and wherein the transport device comprises a temporary storage station disposed on the center line, and robotic devices disposed on both lateral sides of the temporary storage station.

In another aspect of the invention, polishing apparatus, for polishing a circular workpiece attached to a holder device by rotating and pressing a workpiece surface on a rotating polishing surface of a circular polishing tool, comprises: a primary polishing table whose polishing surface radius is larger than a diameter of the workpiece; and a secondary polishing table whose polishing surface radius is smaller than a diameter but larger than a radius of the workpiece.

Such a polishing apparatus is used to carry out a two-step polishing operation. On the first polishing table, high speed polishing is applied to polish a workpiece as in the conventional process while the second polishing table is used to remove micro-scratches or to carry out preliminary cleaning. On the second polishing table, although not all the workpiece surface is in contact with the polishing surface at all times, because of the oscillating motion of the workpiece, the workpiece itself is rotated so that all areas of the workpiece comes into contact with the polishing surface, and results in a uniform material removal. To avoid producing a slanted polished surface, the axis of the workpiece should stay constantly on the polishing surface. The size of the secondary polishing table may be made small in comparison to the very large size of the primary polishing table,

thereby providing a compact apparatus even with an additional polishing device.

In such a polishing apparatus, it may be arranged that the holder device are able to transport a workpiece to both the primary polishing table and the secondary polishing table. The secondary polishing table should be positioned within the swing trace of the wafer holding device, because it revolves about an axis to transfer the workpiece between the polishing unit and a wafer transfer position.

Another aspect of the invention is a polishing apparatus for polishing a circular workpiece attached to a holder device by rotating and pressing a workpiece surface on a rotating polishing surface of a polishing table, wherein a radius of the polishing surface is smaller than a diameter but larger than a radius of the workpiece surface, a center of the workpiece surface stays on the polishing surface, and a distance between a center of the workpiece surface and an edge portion of the polishing surface is smaller than a radius of the workpiece surface. This arrangement is attractive for making the apparatus compact and economical.

**Brief Description of Drawings**

Figure 1 is a schematic plan view of a flow of workpieces with respect to polishing apparatuses in the present polishing apparatus;

Figure 2 is a front view of a polishing unit of the present polishing apparatus;

Figure 3 is a plan view of a polishing unit;

Figure 4A is a side view of a buffing table;

Figure 4B is a side view of a dresser elevating device;

Figure 5A is a plan view of the buffing table;

Figure 5B is a side view of the buffing unit;

Figure 6 is a schematic plan view to show relative positions of the buffing table and the workpiece;

Figure 7 is a cross sectional view of a temporary storage station;

Figure 8 is a plan view to show the actions of the polishing unit;

Figure 9 is a plan view of another example of a flow of workpieces with respect to polishing apparatuses in the present polishing apparatus;

Figure 10 is a front view of another embodiment of the polishing apparatus;

Figure 11 is a schematic plan view of a conventional polishing apparatus; and

Figure 12 is a schematic side view of a conventional polishing apparatus.

## Best Mode for Carrying Out the Invention

In the following, preferred embodiment will be presented with reference to the drawings.

Figure 1 is a schematic illustration of a first embodiment of the present polishing apparatus. The present polishing apparatus is contained in a rectangular-shaped floor space F, and the constituting elements arranged in the left/right lines are disposed in a symmetrical pattern with respect the center line C. Specifically, at one end of a rectangular shaped floor, a pair of polishing units 10a, 10b are disposed symmetrically on left and right, and a loading/unloading unit 12 mounting a pair of cassettes 12a, 12b mounting cassettes 12a, 12b for storing wafers are disposed on the opposite end of the floor. Between these two ends, there are disposed, listing from the loading/unloading unit side, a pair of secondary cleaning units 14a, 14b, a pair of wafer inverters 16a, 16b, and a pair of primary cleaning units 18a, 18b, and one temporary storage station 20. Pairs of primary and secondary cleaning units 18a, 18b and 14a, 14b and a pair of wafer inverters 16a, 16b are disposed opposite to each other across the center line C, and stationary robots

22, 24 having arms with articulating joints are provided on the center line C. On both sides of the temporary storage station 20, stationary robots 26a, 26b are provided.

As shown in Figures 2 and 3, each of the polishing units 10a, 10b is provided with a set of operational devices, disposed approximately parallel to the center line, comprised by: a workpiece pusher 30 for transferring the workpiece W; a top ring device 36 having two top rings 32, 34; a turntable (primary polishing table) 38 having an abrading tool on its top surface; and a dresser 40 for reconditioning the abrading tool. Also, in this embodiment, a buffing table (final polishing table) 42 for performing buffing (final polishing) is disposed next to the top ring device 36.

As shown in Figure 2, the top ring device 36 is comprised by: a vertical support shaft 50 rotatably supported by a base 48 mounted on a bracket 46 laterally protruding from a turntable support base 44; a horizontally extending swing arm 52 attached to the top end of the support shaft 50; and a pair of top rings 32, 34 attached to both ends of the swing arm 52. A swing arm drive motor 47 for oscillating the swing arm around the support shaft 50 is provided in the bracket 46. Each of the top rings 32, 34 has a suction device on the bottom surface to hold a workpiece by vacuum suction, and each is driven by own drive motor 56 so as to enable each to rotate horizontally, and can also be raised or lowered by using an air cylinder 58, independently of the other.

Turntable 38 is a rotatable polishing table having a polishing cloth mounted on the top surface which is basically the same as the turntable shown in Figure 12, and includes a support base 44 for supporting the polishing table, a turntable drive motor 45, and a polishing solution supply nozzle.

As shown in Figures 4 and 5, buffing table 42 includes a small diameter buffing disk 82 having a buffing cloth 80 on the top surface and is rotatable by means of a driving device

86 contained in a housing 84. A dresser 94 including: a rotation driver 88; swing device 90; and an elevating device 92 with an air cylinder 93 is provided adjacent the buffing table 42. The size of the buffing table 42 is such that its radius "R" of the polishing surface is smaller than the diameter "2r" of a workpiece but is larger than its radius "r".

Buffing table 42 is used to perform secondary polishing step on a wafer W which has been through the primary polishing step. The secondary polishing is a finish polishing step carried out by using either polishing solution containing polishing particles, pure water in case of a "water polish", or certain chemical solution. In the example shown in Figure 4A, finish polishing is performed by placing the center of the wafer W at a distance "e" from an edge of the buffing disk 82 to carry out polishing and cleaning. The magnitude of the distance "e" is small in comparison to the radius "r" of the workpiece W. Therefore, as shown in Figure 6, the surface to be polished is exposed outside of the buffing disk 82 in a shape resembling a quarter moon with a maximum width "(r-e)".

In such a setup, the outer peripheral area of the polishing surface of the buffing cloth 80 attached on the disk 82 can provide a maximum polishing ability, where the relative speed to the workpiece surface is larger compared with the inner regions of the disk 82. This polishing region is termed an effective polishing area Ep, as illustrated in Figure 6. Because the workpiece surface is also rotated, each section of the workpiece surface is successively brought into contact with the effective polishing area Ep, and ultimately, amount of material removed from all sections of the workpiece surface is averaged.

To improve the degree of precision of the buffing operation, the distance "e" and rotational speeds as well as polishing duration of the workpiece should be adjusted accordingly. Polishing can be performed while adjusting the distance "e" by rotating the swing arm 52 of the top rings 32, 34, or corrective

polishing can be carried out in the same manner in addition to the normal polishing operation.

With reference to Figure 3, the workpiece pusher 30 is positioned on the opposite side of the support shaft 50 with respect to the turntable 38, and when one top ring 32 (or 34) is on the turntable 38, the other top ring 34 (or 32) is directly above the workpiece pusher 30. Workpiece pusher 30 has a workpiece table 60 which can be raised or lowered, and serves to transfer workpieces between the top rings 32, 34 and robots 26a, 26b. With reference to Figure 2, the bracket 62 extending from the base 44 opposite to the top rings 32, 34 rotatably supports a dresser shaft 64 for the dresser 40.

As shown in Figure 7, the temporary storage station 20 is divided into upper and lower levels. The upper level is a dry station 20A for placing dry workpieces, and the lower level is a wet station 20B for placing wet workpieces. The dry station 20A is an open structure, but the wet station 20B is a closed box structure 68 having spray nozzles 66 disposed on top and bottom of the workpiece. The workpieces W are handled through a gate 70 provided on the side of the box.

The cleaning units 14a, 14b and 18a, 18b can be selected to suit applications, but in this embodiment, the primary cleaning units 18a, 18b beside the polishing units 10a, 10b are made as sponge roller type to scrub both front and back surfaces of a wafer, for example, and the secondary cleaning units 14a, 14b are made to rotate the wafer horizontally by holding the edge of the wafer while supplying a cleaning solution. The latter device can also serve as a spin dryer for dewatering the wafer by centrifugal force.

The wafer inverters 16a, 16b are needed in this embodiment, because of the wafer storage method using cassettes 12a, 12b and their working relation to the handling mechanism of the robots, but such devices are not needed for a system where the polished wafers are transported with the polished surface always

facing downward, for example. Also, such inverters 16a, 16b are not needed where the robots comprise inverting facilities. In this embodiment, the two wafer inverters 16a, 16b are assigned separately to handling dry wafers and to handling wet wafers.

In this embodiment, four robots 22, 24, 26a, 26b are provided, and they are of a stationary type operating with articulating arms having a hand at the ends. The first robot 22 handles workpieces for a pair of cassettes, secondary cleaning units 14a, 14b and the wafer inverters 16a, 16b. The second robot 24 handles workpieces for a pair of wafer inverters 16a, 16b, primary cleaning units 18a, 18b and temporary storage station 20. The third and fourth robots 26a, 26b handle workpieces for temporary storage station 20, either one of the cleaning units 18a or 18b and either one of the workpiece pushers 30.

The polishing apparatus can be used for series or parallel operation as explained in the following. Figure 1 shows flow of workpieces W in parallel operation using one cassette in the loading/unloading unit. In the following description, the processing line which is in the top section in Figure 1 is designated as the "right" processing line, and the processing line which is in the bottom section is designated as the "left" processing line. Here, wafer (workpiece) W is shown by a blank circle when its work surface (polished surface) is directed upwards, by a densely meshed circle when its work surface is directed downwards, and by a sparsely meshed circle when it is inverted.

The flow of workpieces (semiconductor wafers) W in the right processing line for parallel processing is as follows: right cassette 12a → first robot 22 → dry inverter 16a → second robot 24 → dry station 20A → third robot 26a → workpiece pusher 30 for right polishing unit 10a → top ring 32 or 34 → polishing on turntable 38 → if necessary, buffing on buffing table 42 → workpiece pusher 30 → third robot 26a → primary cleaning unit 18a → second robot 24 → wet inverter 16b → first robot 22 →

secondary cleaning unit 14a → right cassette 12a.

Processing flow in each polishing unit 10a, 10b will be explained with reference to Figures 8A~8C. Workpiece pusher 30 already is provided with a new unpolished wafer delivered by the third robot 26a (or fourth robot 26b). As shown in Figure 8A, polishing is performed by using the top ring 32 holding the wafer, and during this time, the other top ring 34 is above the workpiece pusher 30 and receives an unpolished wafer. After finishing polishing on the turntable 38, top ring 32 moves over to the buffing table 42 by the swing action of the swing arm 52, as shown in Figure 8B, to carry out buffing, dual-purpose water polishing for concurrently performing finishing as well as cleaning. The wafer may also be transferred directly by the workpiece pusher 30 after the primary polishing.

When the water polishing is finished, the swing arm 52 is rotated and the top ring 32 is moved directly over the workpiece pusher 30, as shown in Figure 8C. Then, the polished wafer is transferred to the workpiece pusher 30 by either lowering the top ring 32 or raising the workpiece pusher 30. The polished wafer is replaced with a new unpolished wafer by using third robot 26a (or fourth robot 26b). During this period, the other top ring 34 is moved over to the turntable 38, and the wafer is polished on the turntable 38, and further, as shown in Figure 8D, moves over to the buffing table 42 by the swing action of the swing arm 52. The polished wafer is water polished for finishing and cleaning, and the process begins all over from the step shown in Figure 8A.

In the above process, because robots 26a, 26b are provided for each processing line for handling the wafers for polishing units 10a, 10b, the polished wafer on the workpiece pusher 30 is quickly exchanged with a new unpolished wafer. Therefore, there is no waiting time for the top ring 32, 34 for the next wafer to be polished, and the idle time for the turntable 38 is reduced.

On the contrary, since the wafer exchange is rapidly performed, top rings 32, 34 may wait for the turntable 38 to finish polishing while holding an unpolished wafer by vacuum. In this case, if the wafer is clamped by vacuum for a long time, a backing film provided between the wafer and the top ring 32, 34 will be deformed. Therefore, in this embodiment, the top rings 32, 34 are programmed to release the vacuum when a long term waiting is expected. The wafer is maintained on the lower surface of the top rings 32, 34 by remaining adhesion forces of wet backing film.

Also, in this embodiment, because the top ring device 36 is provided with two top rings 32, 34 disposed on the both ends of the swing arm 52, while one wafer is being processed by one top ring, the wafer on the other top ring is replaced with a new unpolished wafer. Therefore, there is no need to wait for the top rings 32, 34 for the wafer to be transferred for processing. Therefore, the through-put of the turntable 38 is increased, thereby enabling to perform high efficiency parallel operation.

Through-put by the facility shown in Figure 1 will be compared with that by the conventional facility shown in Figure 11. Assume that polishing time of a wafer is two minutes, and that cleaning is carried out by primary and secondary cleaning steps. In the conventional setup, forty wafers are polished in one hour while in the present facility, fifty three wafers are polished. Comparing the through-put per unit area of installation space, it is 7.4 wafers/$m^2\cdot$hour for the conventional system, while in the present facility, it is 7.9 wafers/$m^2\cdot$hour.

Figure 9 shows a flow process for two-step polishing, i.e., a series operation. The process is as follows: right cassette 12a → first robot 22 → dry inverter 16a → second robot 24 → dry station 20A → third robot 26a → first polishing unit 10a → third robot 26a → right primary cleaning unit 18a → second robot 24 → wet station 20B → third robot 26b → secondary polishing unit 10b → third robot 26b → left primary cleaning

unit 18b → second robot 24 → wet inverter 16b → first robot 22 → left secondary cleaning unit 14b → first robot 22 → right cassette 12a.

In this series processing operation, because wet wafer is supplied to polishing unit 10b, the dry station 20A and the wet station 20B are separately used for placing dry wafers and wet wafers respectively. In the wet station 20B, the top and bottom surfaces of the wafer W is rinsed with rinsing solution to prevent drying of the polished wafer. It should be noted that the wet and dry stations 20A, 20B are separately shown in Figure 9 for convenience in flow illustration, but they are stacked vertically, as shown in Figure 7.

Figure 10 shows another embodiment according to the present invention. In this polishing unit, a film thickness measuring device 72 is provided adjacent the top ring 34 located above the workpiece pusher 30 for measuring the film thickness of a wafer held in the top ring 34. The film thickness measuring device 72 is comprised by: an optical head 74 attached at the tip of an arm 76 for performing non-contact measurement of film thickness; and a positioning device 78 such as an x-y table for moving the arm 76 along the workpiece surface.

Using this arrangement, it is possible to measure film thickness fabricated on a polished wafer held on the top ring 34 when the swing arm 52 is rotated in position shown in Figure 10. The thickness measurement provides a basis for determining the amount of material removed so that, if necessary, polishing time for the next wafer may be adjusted by a feedback control device. Or, if the value has not yet reached an allowable range, control device may rearrange polishing schedule so that it can be repolished. The advantage is that there is no need to provide a separate space for determining the film thickness of a polished wafer, by enabling to determine the thickness in-place above the workpiece pusher. The time required to exchange the wafers by the third or fourth robots 26a, 26b is shorter than the time

required by the turntable 38 to polish a wafer, therefore, such film measurement can be performed during this time without generating any down time of the line.

## Industrial Applicability

The present invention is useful for polishing workpieces, such as semiconductor wafers, glass plates and liquid crystal display panels which require a high surface flatness.

**CLAIMS**

1. A polishing apparatus comprising:

a storage section for storing a workpiece to be polished;

at least two processing lines extending substantially in parallel from said storage section, each line being provided with a cleaning unit and a polishing unit;

a temporary storage station disposed between said cleaning unit and said polishing unit and shared by said processing lines; and

at least two robotic devices disposed on each of said processing lines for transferring workpieces among said temporary storage station, said polishing unit and said cleaning unit.

2. A polishing apparatus according to claim 1, wherein said polishing unit is provided with a turntable, a top ring device and a workpiece pusher to facilitate transfer of a workpiece to and from said robotic device.

3. A polishing apparatus according to claim 2, wherein said top ring device is comprised by two top rings for holding a wafer respectively, which can be positioned to work with said turntable and with said workpiece pusher, and a swing arm for supporting said top rings rotatably in a horizontal plane.

4. A polishing apparatus according to claim 3, wherein said polishing unit is provided with a film thickness measuring device for remotely measuring thickness of a film formed on a workpiece being held on said top ring.

5. A polishing apparatus according to claim 2, wherein said polishing unit is provided with a buffing table having a buffing disk.

6. A polishing apparatus comprising:

a storage section for storing a workpiece disposed at one end of an installation floor space;

two polishing units disposed on opposite end of said installation floor space, each polishing unit having a turntable, a top ring device and a workpiece pusher;

at least two cleaning units for cleaning polished workpieces produced in said polishing units; and

a transport device for transferring workpieces between processing units,

wherein a group of polishing and cleaning units and another group of polishing and cleaning units are disposed symmetrically opposite to each other across a center line extending from said one end to said opposite end of said installation floor space, and

wherein said transport device comprises a temporary storage station disposed on said center line, and robotic devices disposed on both lateral sides of said temporary storage station.

7. A polishing apparatus, for polishing a circular workpiece attached to a holder device by rotating and pressing a workpiece surface on a rotating polishing surface of a circular polishing tool, comprising:

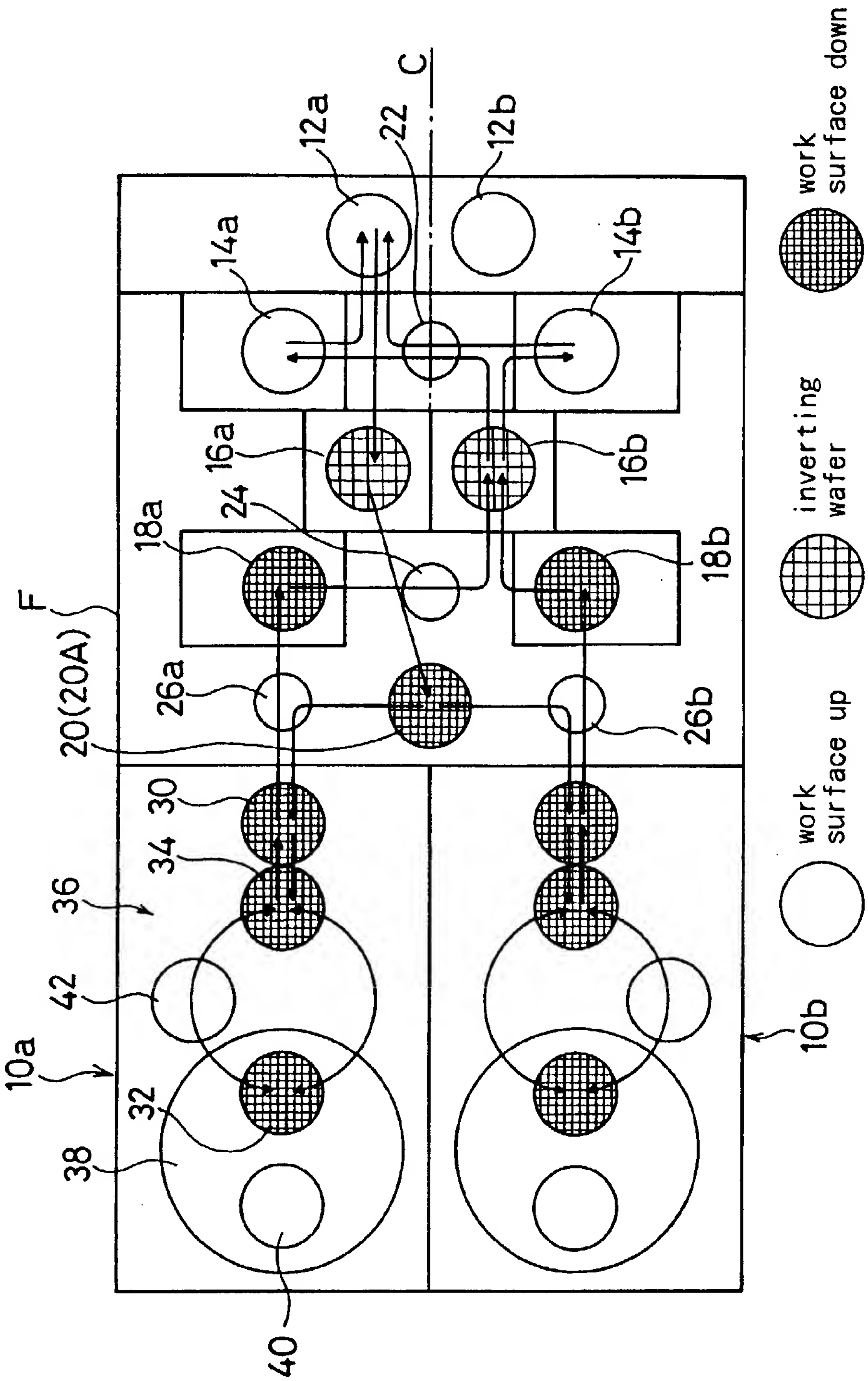
a primary polishing table whose polishing surface radius is larger than a diameter of said workpiece; and

a secondary polishing table whose polishing surface radius is smaller than a diameter but larger than a radius of said workpiece.

8. A polishing apparatus according to claim 7, wherein said holder device is able to transport a workpiece to both said primary polishing table and said secondary polishing table.

9. A polishing apparatus for polishing a circular workpiece attached to a holder device by rotating and pressing a workpiece surface on a rotating polishing surface of a polishing table,

wherein a radius of said polishing surface is smaller than a diameter but larger than a radius of said workpiece surface, a center of said workpiece surface stays on said polishing surface, and a distance between a center of said workpiece surface and an edge portion of said polishing surface is smaller than a radius of said workpiece surface.


C
12a
22
12b
14a
14b
16a
16b
24
18a
18b
F
26a
26b
20(20A)
30
34
36
42
10a
32
38
40
10b
work surface down
inverting wafer
work surface up

F / G. 1

F I G. 2

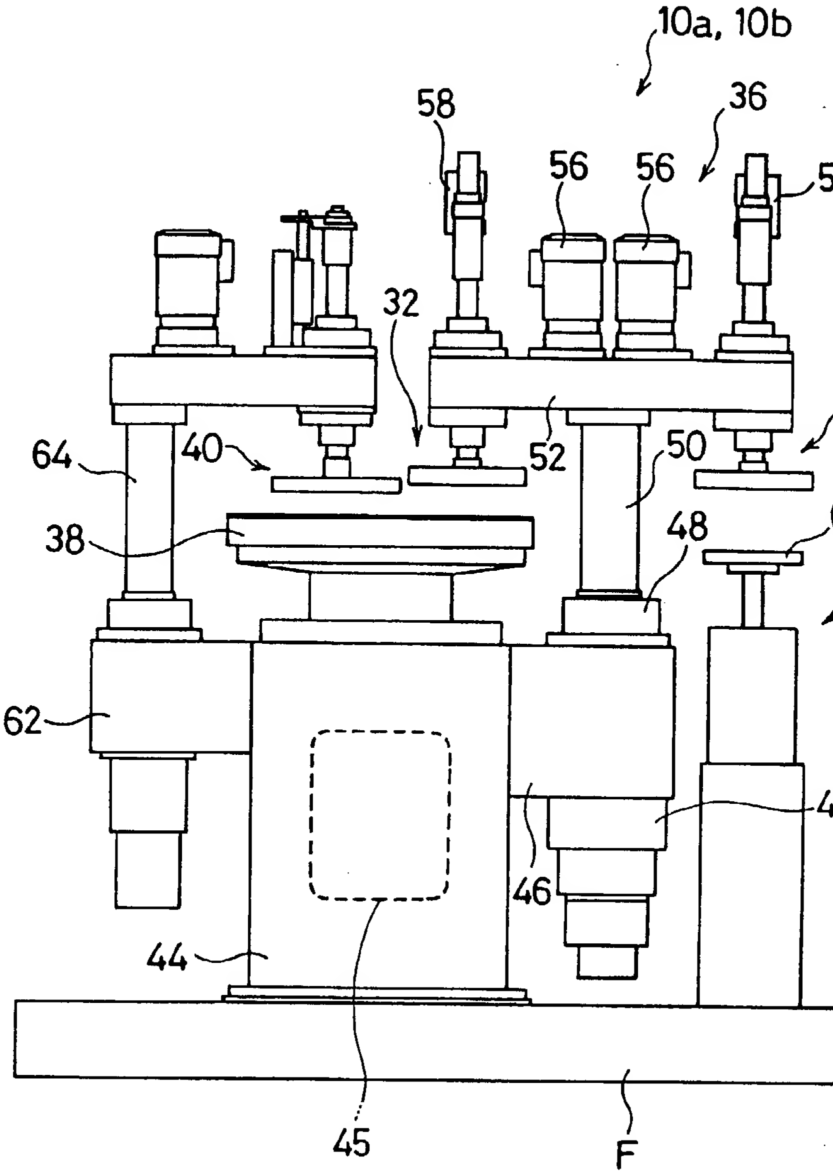
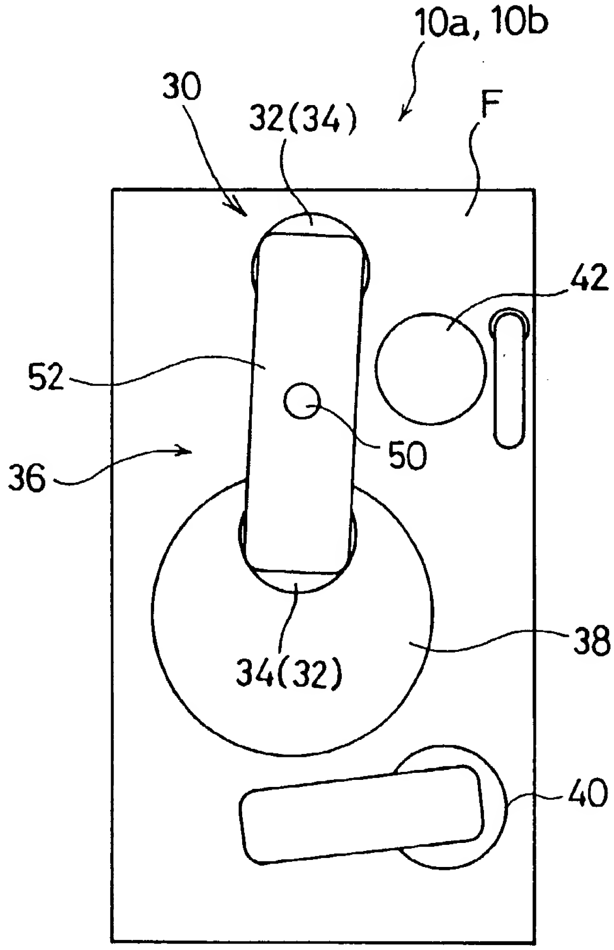
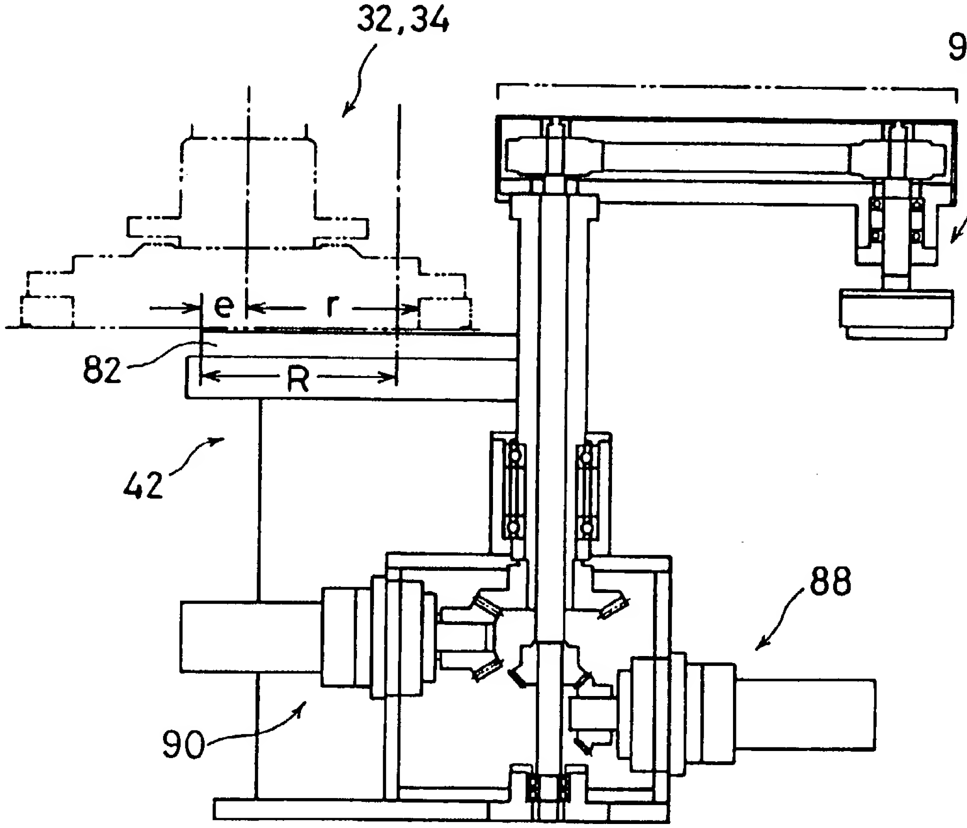


FIG. 3



F I G. 4 A




F I G. 4 B

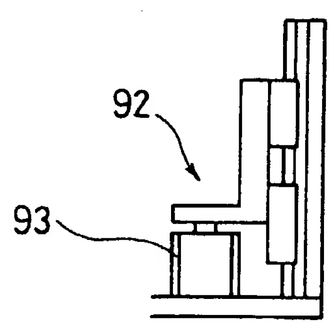


FIG. 5A

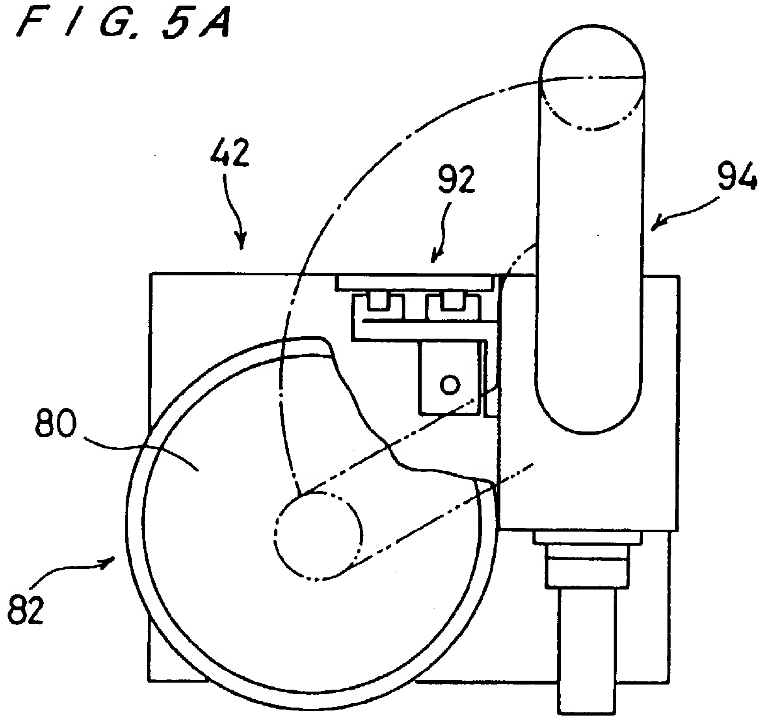



FIG. 5B

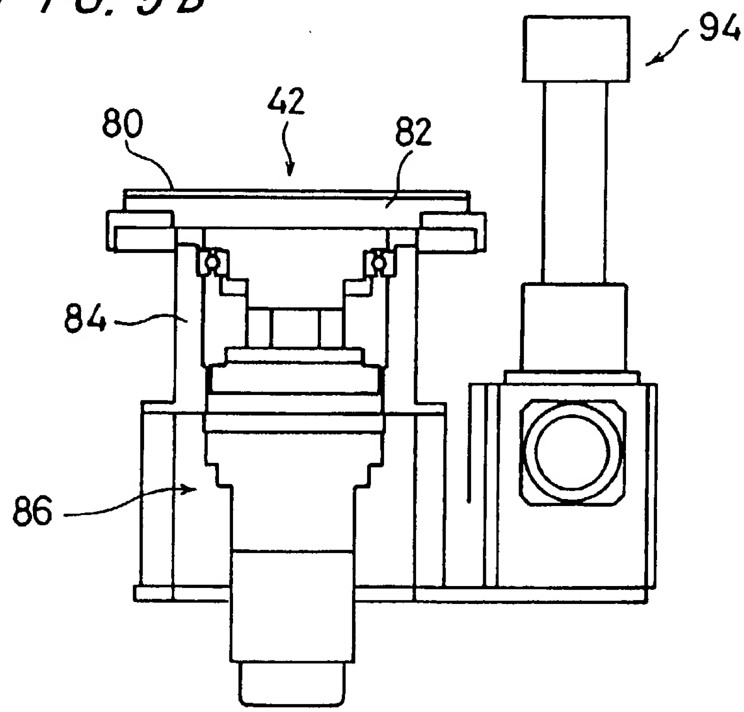
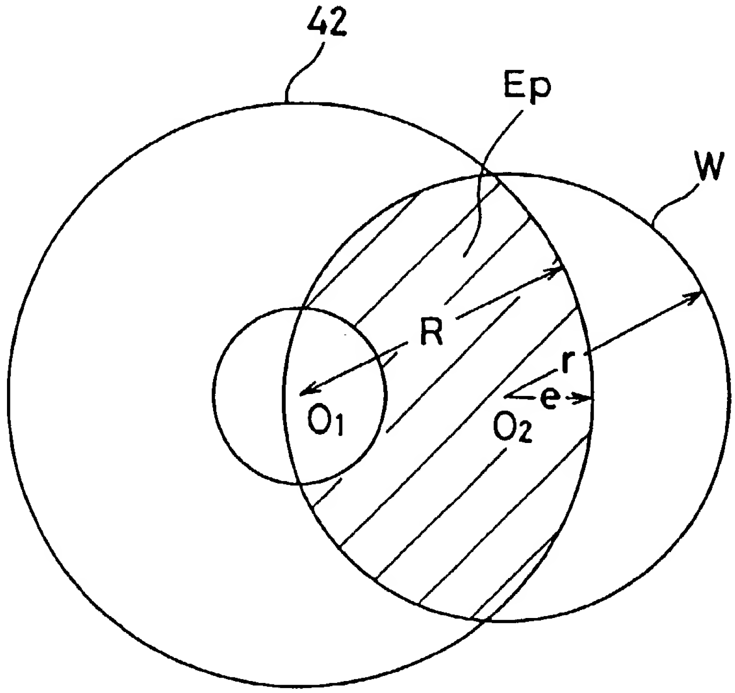
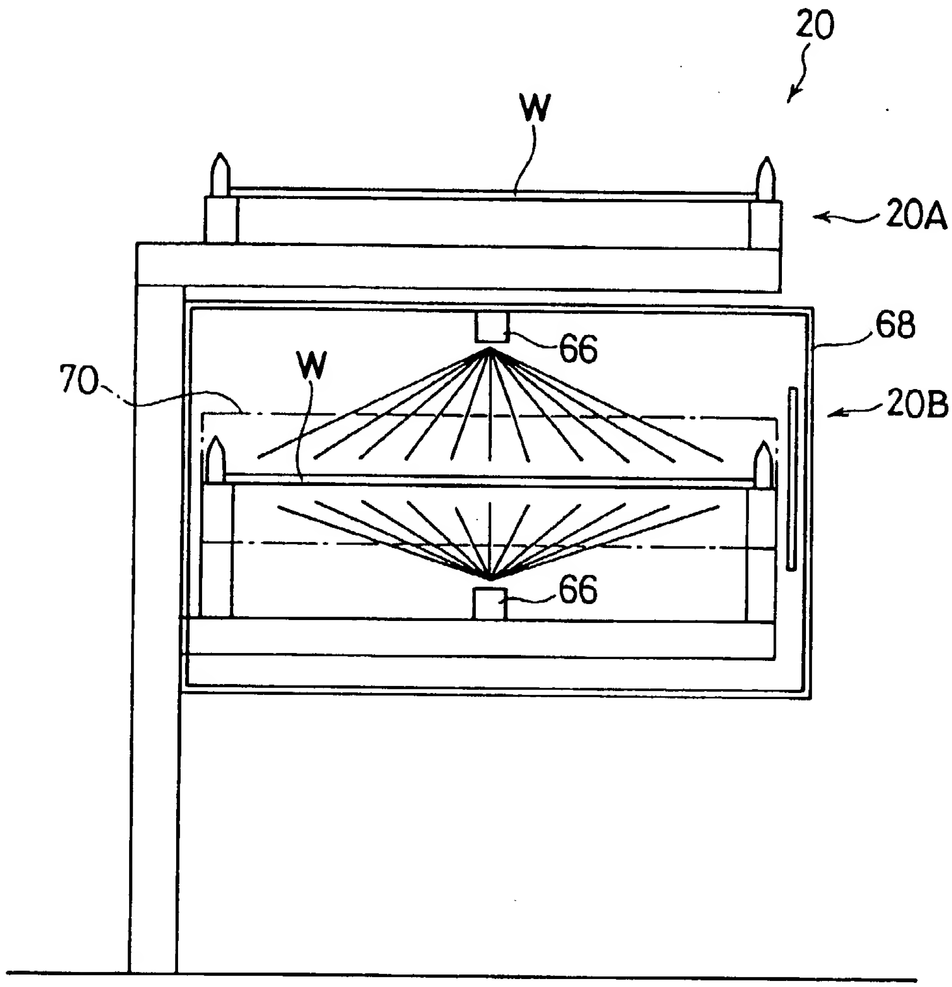


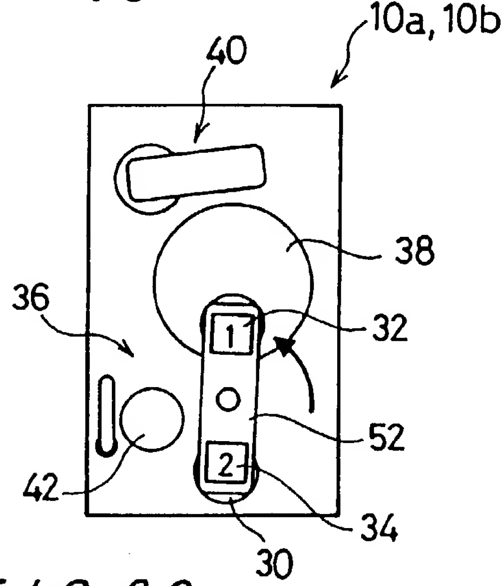
FIG. 6



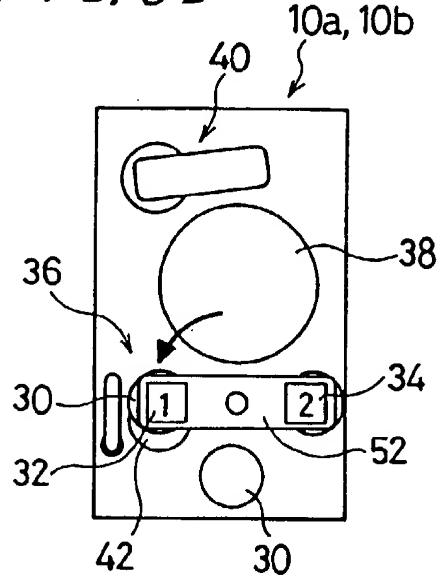
F I G. 7



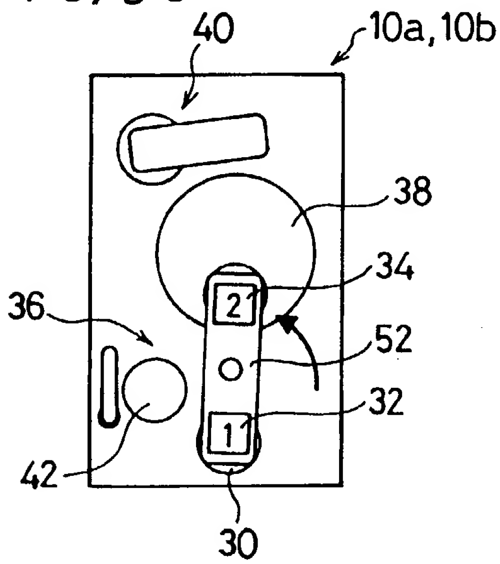
F I G. 8 A




F I G. 8 B




F I G. 8 C




F I G. 8 D

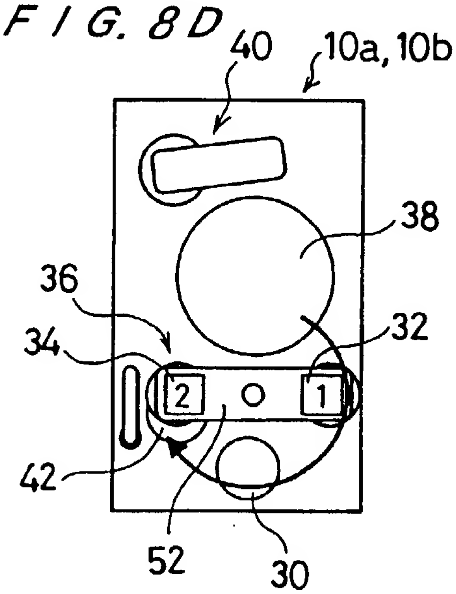
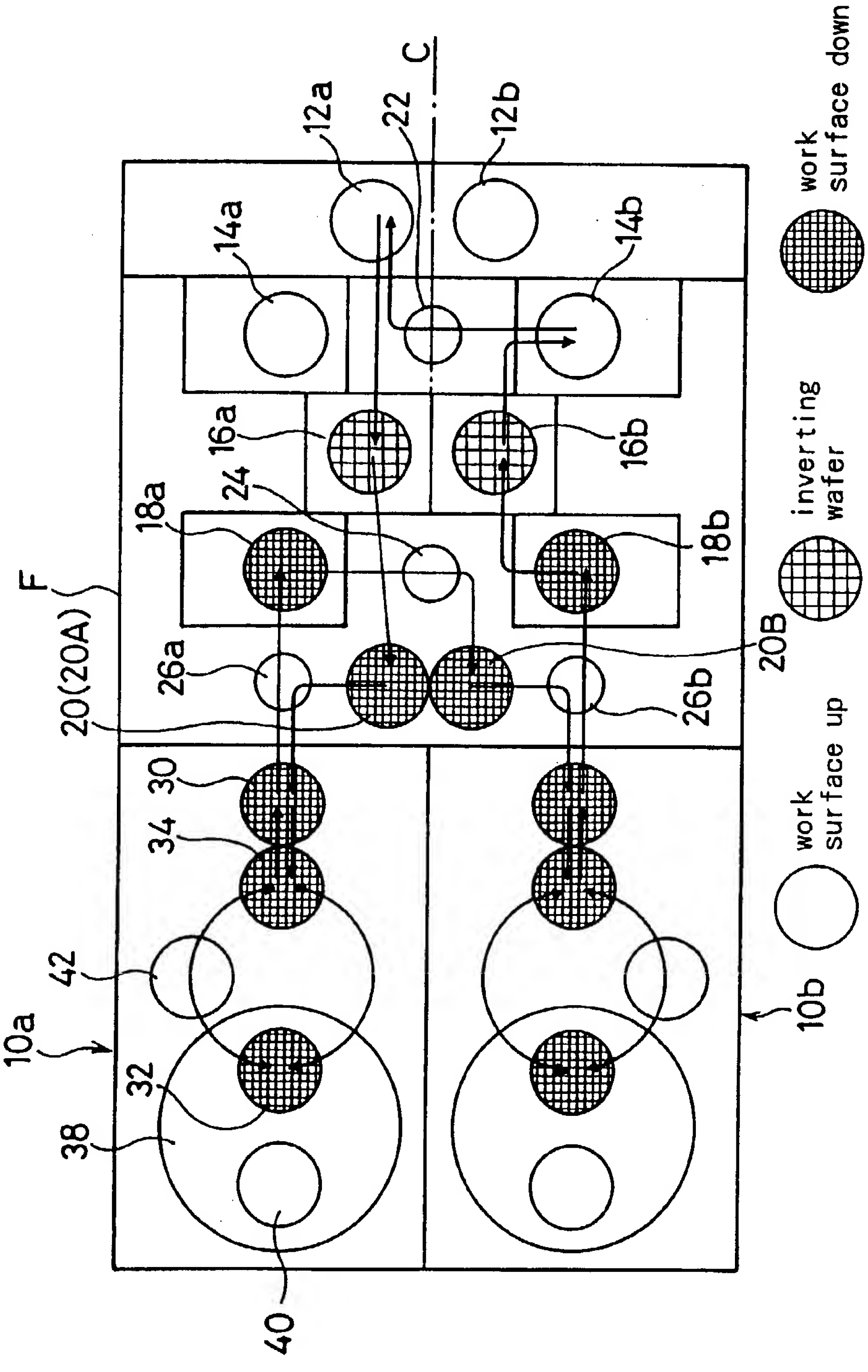
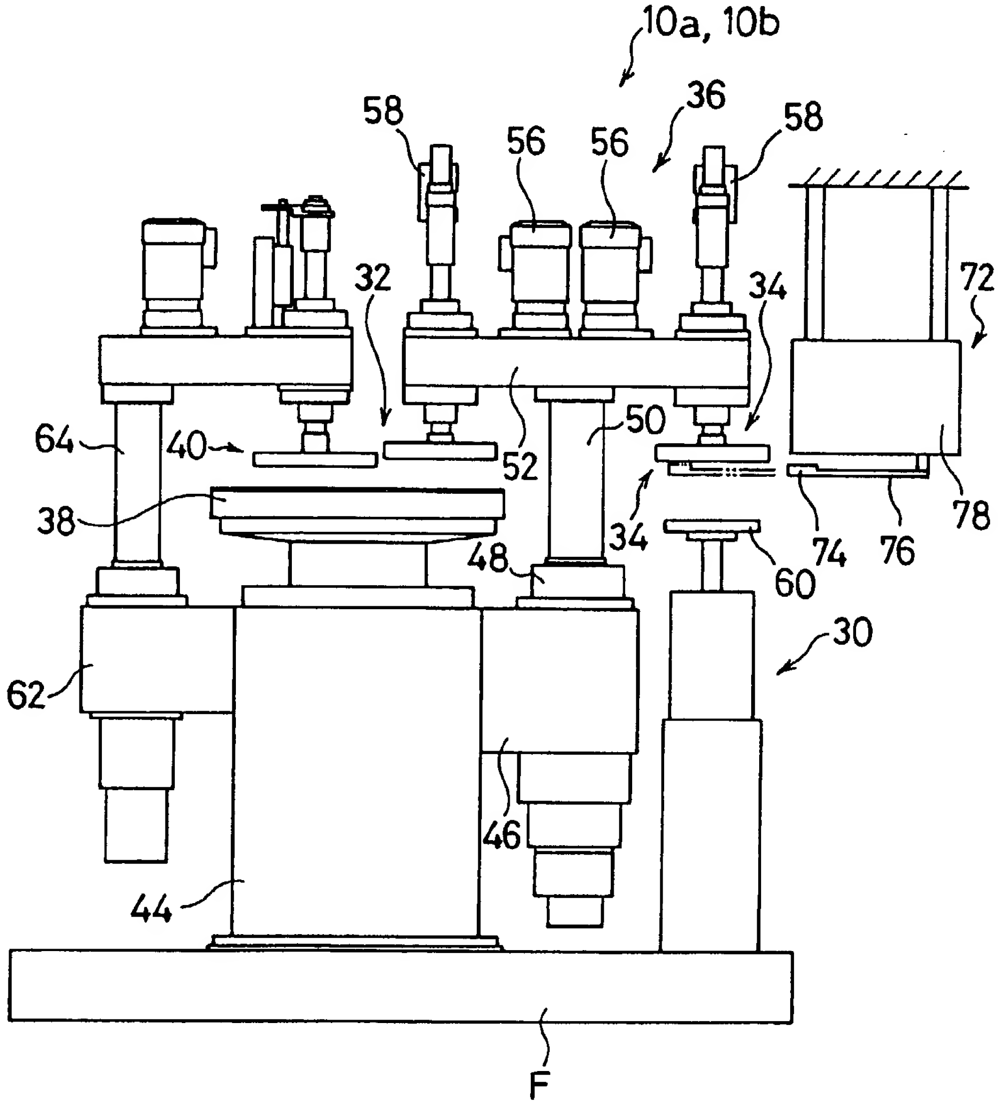


FIG. 9

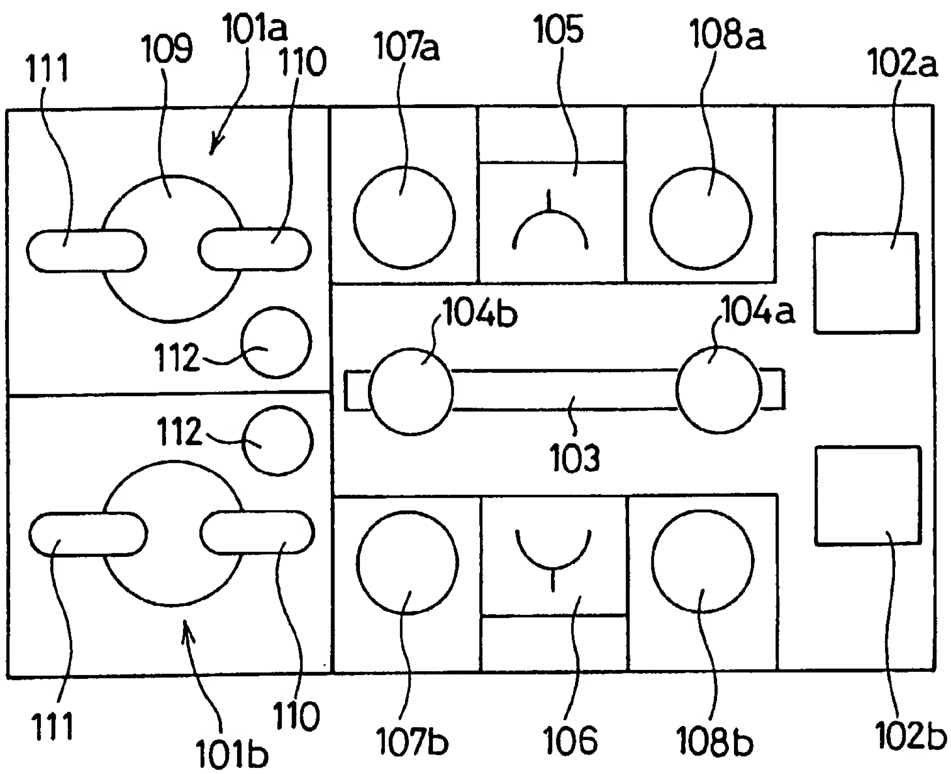

C
12a
22
12b
14a
14b
16a
24
16b
18a
18b
F
26a
20B
20(20A)
26b
30
34
42
10a
32
38
40
10b
work surface down
inverting wafer
work surface up

F I G. 1 0


10a, 10b
58
56
56
36
58
32
34
72
64
40
52
50
38
34
48
60
74
76
78
30
62
46
44
F

F I G. 1 1

PRIOR ART



F I G. 1 2

PRIOR ART